

WHAT IS CLAIMED IS:

1. A temperature compensation circuit, comprising:

a plurality of first modules each effective for producing a respective first signal directly proportional to temperature

a plurality of second modules each effective for producing a respective second signal inversely proportional to temperature;

a first summing node for summing all of said first and second signals and producing a resultant summed signal.

2. The temperature compensation circuit of claim 1, wherein:

the strength of each first signal of said plurality of first modules is individually selectable; and

the strength of each second signal of said plurality of second modules is individually selectable

3. The temperature compensation circuit of claim 1, wherein said plurality of first modules have differing temperature characteristic curve shapes.

4. The temperature compensation circuit of claim 1, wherein said plurality of second modules have differing temperature characteristic curve shapes.

5. The temperature dependent signal generator of claim 1, wherein each of said plurality of first modules has an optionally assigned first temperature offset, wherein each of said plurality of first modules is precluded from outputting its respective first signal for temperatures below its respectively assigned first temperature offset.

6. The temperature dependent signal generator of claim 5, wherein said plurality of first modules have differing first temperature offset values.

7. The temperature dependent signal generator of claim 1, wherein each of said plurality of second modules has an optionally assigned second temperature

offset, wherein each of said plurality of second modules is precluded from outputting its respective second signal for temperatures below its respectively assigned second temperature offset.

8. The temperature dependent signal generator of claim 7, wherein said plurality of second modules have differing second temperature offset values.

9. The temperature dependent signal generator of claim 1, wherein:

each of said plurality of first modules has an optionally assigned first temperature offset, wherein each of said plurality of first modules is precluded from outputting its respective first signal for temperatures below its respectively assigned first temperature offset; and

each of said plurality of second modules has an optionally assigned second temperature offset, wherein each of said plurality of second modules is precluded from outputting its respective second signal for temperatures below its respectively assigned second temperature offset.

10. The temperature dependent signal generator of claim 9, wherein:

said plurality of first modules have differing first temperature offset values; and

said plurality of second modules have differing second temperature offset values.

11. The temperature compensation circuit of claim 1, wherein each of said plurality of first modules and each of said plurality of second modules includes a first CTAT signal source.

12. The temperature compensation circuit of claim 11, wherein at least one of said plurality of first modules further includes:

a CTAT signal source;

a PTAT signal source;

a second summing node for creating a difference signal based on the difference in signal magnitude of said CTAT signal source and said PTAT signal source;

and a first dependent signal generator for producing an intermediate signal dependent on said difference signal.

13. The temperature compensation circuit of claim 12, wherein said dependent signal generator produces said intermediate signal only if said difference signal is above a predetermined threshold value.

14. The temperature compensation circuit of claim 12, wherein said difference signal is a measure of a temperature offset, wherein said at least one of said plurality of first modules produces substantially no signal for temperatures below said temperature offset.

15. The temperature compensation circuit of claim 12, wherein:

for temperatures lower than a predefined transition temperature the magnitude of said CTAT signal source is greater than said PTAT signal source; and

for temperatures higher than said predefined transition temperature the magnitude of said PTAT signal source is greater than said CTAT signal source.

16. A temperature compensated oscillator comprising:

the temperature compensation circuit of claim 1;

a variable frequency oscillator responsive to the output of said first summation node.

17. The temperature compensation oscillator of claim 16, wherein said variable frequency oscillator is a surface acoustic wave resonator.

18. An electronic device including the temperature compensation circuit of claim 1.

19. A temperature compensation circuit, comprising:

a first temperature dependent signal generator having a first activation temperature, said first temperature dependent signal generator being effective for producing a first signal proportional to temperature when temperature is not lower than said first activation temperature and for producing substantially no signal when temperature is below said first activation temperature;

a second temperature dependent signal generator, said second temperature dependent signal generator being effective for producing a second signal inversely proportional to temperature when temperature is not lower than said second activation temperature;

a summing node for summing said first signal and said second signal and outputting the result on a first summation output node.

20. The temperature compensation circuit of claim 19, wherein said second temperature dependent signal generator has a second activation temperature, and wherein said second temperature dependent signal generator is further effective for producing substantially no signal when temperature is below said second activation temperature.

21. The temperature compensation circuit of claim 20, wherein said first activation temperature is higher than said second activation temperature.

22. The temperature compensation circuit of claim 19, wherein said first temperature dependent signal generator includes:

a first signal source for producing a first sub-signal inversely proportional to temperature;

a second signal source for producing a second sub-signal directly proportional to temperature; and

a second summing node for subtracting the magnitude of said first sub-signal from the magnitude of said second sub-signal.

wherein for temperatures lower than a predefined transition temperature the magnitude of said first sub-signal is not less than the magnitude of said second sub-signal, and for temperatures not lower than said predefined transition temperature the magnitude of said first sub-signal is less than the magnitude of said second sub-signal;

23. The temperature compensation circuit of claim 22, wherein said first signal source includes a complementary to absolute temperature (CTAT) circuit and said second signal source includes a proportional to absolute temperature (PTAT) circuit.

24. The temperature compensation circuit of claim 22, wherein said predefined transition temperature is proximate to said first activation temperature.

25. The temperature compensation circuit of claim 22, wherein said predefined transition temperature is lower than said first activation temperature.

26. The temperature compensation circuit of claim 22, wherein said predefined transition temperature is said first activation temperature.

27. The temperature compensation circuit of claim 22, wherein said first signal of said first temperature dependent signal generator is output from said second summation output node.

28. The temperature compensation circuit of claim 22 wherein said first and second sub-signals are voltage signals, and wherein said second summation node is a difference amplifier having an inverting input coupled to receive said first sub-signal and having a non-inverting input coupled to receive said second sub-signal.

29. The temperature compensation circuit of claim 22 wherein said first and second sub-signals are current signals, and wherein said second summation node is a circuit junction node, wherein:

a first lead couples said first signal source to said circuit junction node, a second lead couples said second signal source to said circuit junction node, and a third lead coupled to said circuit junction node outputs the resultant difference of said first and second sub-signals.

30. The temperature compensation circuit of claim 29 wherein said first signal source is a current source having its output coupled to said junction node by said first lead, and said second signal source is a current sink having its input coupled to said junction node by said second lead.

31. The temperature compensation circuit of claim 22, wherein said first temperature dependent signal generator further includes:

a first dependent signal generator for generating a weighted signal dependent on the output from said second summation output node.

32. The temperature compensation circuit of claim 31, wherein said weighted signal is said first signal of said first temperature dependent signal generator.

33. The temperature compensation circuit of claim 31, wherein said first dependent signal generator is effective for producing substantially no output signal when the output of said second summation output node is less than a predefined threshold value, and for producing said weighted signal when the output of said second summation output node is not less than said predefined threshold value.

34. The temperature compensation circuit of claim 31, wherein said first dependent signal generator is effective for producing substantially no output signal when the difference of the output magnitude of said first and second signal sources is a negative, and producing said weighted signal when the output of said second summation output node is positive.

35. The temperature compensation circuit of claim 31, wherein said first dependent signal generator is a transistor having a control input responsive to said second summation output node.

36. The temperature compensation circuit of claim 31, wherein said first dependent signal generator is a current mirror having a control input responsive to said second summation output node.

37. The temperature compensation circuit of claim 19, wherein said first signal and said second signal are voltage signals, and wherein said first summation node is a summing amplifier having a first summing input coupled receive said first signal and a second summing input coupled to receive said second signal.

38. The temperature compensation circuit of claim 19 wherein said first signal and said second signal are current signals, and wherein said first summation node is a junction node having a first lead coupled to receive said first signal, a second lead coupled to receive said second signal, and a third lead coupled to produce said first summation output node.

39. The temperature compensation circuit of claim 19, wherein said second temperature dependent signal generator further includes:

a third sub-signal source; and

a second dependent signal generator for generating a second weighted signal dependent on the output from said third sub-signal source.

40. The temperature compensation circuit of claim 39, wherein said sub-signal source includes a complementary to absolute temperature (CTAT) circuit.

41. The temperature compensation circuit of claim 39, wherein said second weighted signal is said second signal of said second temperature dependent signal generator.

42. The temperature compensation circuit of claim 39, wherein said second dependent signal generator is a transistor having a control input responsive to said third sub-signal source.

43. The temperature compensation circuit of claim 39, wherein said second dependent signal generator is a current mirror having a control input responsive to said third sub-signal source.

44. The temperature compensation circuit of claim 19, further comprising:

a transimpedance amplifier having an input coupled to said first summation node;

a voltage controlled oscillator responsive to said transimpedance amplifier.

45. The temperature compensation circuit of claim 19, further comprising:

a transconductance amplifier having an input coupled to said first summation node;

a current controlled oscillator responsive to said transconductance amplifier.

46. A temperature compensated oscillator comprising:

the temperature compensation circuit of claim 19;

a variable frequency oscillator responsive to the output of said first summation node.

47. The temperature compensation oscillator of claim 46, wherein said variable frequency oscillator is a surface acoustic wave resonator.

48. An electronic device including the temperature compensation circuit of claim 19.

49. A temperature compensation circuit, comprising:

a first temperature dependent current signal generator having a first activation temperature, said first temperature dependent current signal generator being effective for producing a first current signal proportional to temperature when temperature is not lower than said first activation temperature and for producing substantially no signal when temperature is below said first activation temperature;

a second temperature dependent current signal generator, said second temperature dependent signal generator being effective for producing a second current signal inversely proportional to temperature;

a first summing node for summing said first current signal and said second current signal and outputting the resultant on a first summation output node.

50. The temperature compensation circuit of claim 49, wherein said second temperature dependent current signal generator has a second activation temperature, and wherein said second temperature dependent current signal generator produces said second current signal when temperature is not lower than said second activation temperature.

51. The temperature compensation circuit of claim 50, wherein said first activation temperature is higher than said second activation temperature; and

52. The temperature compensation circuit of claim 49, wherein said first temperature dependent current signal generator includes:

a first current source inversely proportional to temperature; and

a first current sink directly proportional to temperature; and

a second summing node having a first lead coupled to said current source and a second lead coupled to current sink;

wherein for temperatures lower than a predefined transition temperature the magnitude of the output current of said first current source is

not less than the magnitude of the sinking current of said current sink, and for temperatures not lower than said predefined transition temperature the magnitude the output current of said current source is less than the magnitude of the sinking current of said current sink.

53. The temperature compensation circuit of claim 52, wherein said predefined transition temperature is proximate to said first activation temperature.

54. The temperature compensation circuit of claim 52, wherein said predefined transition temperature is lower than said first activation temperature.

55. The temperature compensation circuit of claim 52, wherein said predefined transition temperature is said first temperature.

56. The temperature compensation circuit of claim 52, wherein said first current signal of said first temperature dependent current signal generator is output from said second summation output node.

57. The temperature compensation circuit of claim 52, wherein said first temperature dependent current signal generator further includes:

a first dependent current source coupled to said second summing node through a third lead, wherein said dependent current source produces a weighted current dependent upon the current through said third lead.

58. The temperature compensation circuit of claim 57, wherein said weighted signal is said first signal of said first temperature dependent current signal generator.

59. The temperature compensation circuit of claim 57, wherein said first dependent current source is effective for producing substantially no output current signal when the current through said third lead is less than a predefined threshold value, and for producing said weighted current signal when the current through said third lead is not less than said predefined threshold value.

60. The temperature compensation circuit of claim 57, wherein said first dependent current source includes a transistor having a control input coupled to said output lead.

61. The temperature compensation circuit of claim 60, wherein said transistor is a BJT transistor.

62. The temperature compensation circuit of claim 60, wherein said transistor is an MOS transistor.

63. The temperature compensation circuit of claim 57, wherein said first dependent current source is a current mirror having a control input responsive to said second summation output node.

64. The temperature compensation circuit of claim 63, wherein said current mirror includes a diode-connected transistor coupled to said third lead, and includes an output transistor response to the said diode-connected transistor.

65.. The temperature compensation circuit of claim 52, wherein said first current source includes a complementary to absolute temperature (CTAT) circuit and said first current sink includes a proportional to absolute temperature (PTAT) circuit.

66. The temperature compensation circuit of claim 49, wherein said second temperature dependent signal generator further includes:

a sub-signal source; and

a second dependent current source for generating a second weighted signal dependent on the output from said sub-signal source.

67. The temperature compensation circuit of claim 66, wherein said sub-signal source includes a complementary to absolute temperature (CTAT) circuit.

68. The temperature compensation circuit of claim 66, wherein said sub-signal source is a second current source.

69. The temperature compensation circuit of claim 66, wherein said sub-signal source is a second current sink.

70. The temperature compensation circuit of claim 66, wherein said second dependent current source includes a transistor.

71. The temperature compensation circuit of claim 70, wherein said transistor is a BJT transistor.

72. The temperature compensation circuit of claim 70, wherein said transistor is an MOS transistor.

73. The temperature compensation circuit of claim 66, wherein said second dependent current source is a current mirror having a control input responsive to said sub-signal source.

74. The temperature compensation circuit of claim 73, wherein said current mirror includes a second diode-connected transistor responsive to said sub-signal source, and includes a second output transistor response to the said second diode-connected transistor.

75. The temperature compensation circuit of claim 66, wherein said second weighted signal is said second signal of said second temperature dependent signal generator.

76. A temperature compensated oscillator comprising:

the temperature compensation circuit of claim 49;

a variable frequency oscillator responsive to the output of said first summation node.

77. The temperature compensation oscillator of claim 76, wherein said variable frequency oscillator is a current controlled oscillator.

78. The temperature compensation oscillator of claim 76, of wherein said variable frequency oscillator is a voltage controlled oscillator coupled to said first summation node through a current-to-voltage converter.

79. An electronic device including the temperature compensation circuit of claim 49.

80. A temperature compensation circuit, comprising:

a first temperature dependent voltage signal generator having a first activation temperature, said first temperature dependent voltage signal generator being effective for producing a first voltage signal proportional to temperature when temperature is not lower than said first activation temperature and for producing substantially no signal when temperature is below said first activation temperature;

a second temperature dependent voltage signal generator effective for producing a second voltage signal inversely proportional to temperature;

a summing node for summing said first signal and said second signal and outputting the result on a first summation output node.

81. The temperature compensation circuit of claim 80, wherein said second temperature dependent voltage signal generator has a second activation temperature, and said second temperature dependent current signal generator produces said second current signal when temperature is not lower than said second activation temperature.

82. The temperature compensation circuit of claim 81, wherein said first activation temperature is higher than said second activation temperature; and

83. The temperature compensation circuit of claim 80, wherein said first temperature dependent voltage signal generator includes:

a first voltage source inversely proportional to temperature;

a second voltage source directly proportional to temperature;

a second summing node for subtracting the magnitude of said first voltage source from the magnitude of said second voltage source;

wherein for temperatures lower than a predefined transition temperature the magnitude of said first voltage source is not less than the magnitude of said second voltage source, and for temperatures not lower than said predefined transition temperature the magnitude of said first voltage source is less than the magnitude of said second voltage source;

84. The temperature compensation circuit of claim 83, wherein said first voltage source includes a complementary to absolute temperature (CTAT) circuit and said second voltage source includes a proportional to absolute temperature (PTAT) circuit.

85. The temperature compensation circuit of claim 83, wherein said predefined transition temperature is proximate to said first activation temperature.

86. The temperature compensation circuit of claim 83, wherein said predefined transition temperature is lower than said first activation temperature.

87. The temperature compensation circuit of claim 83, wherein said predefined transition temperature is said first temperature.

88. The temperature compensation circuit of claim 83, wherein said first voltage signal of said first temperature dependent voltage signal generator is output from said second summation output node.

89. The temperature compensation circuit of claim 83 wherein said second summation node is a difference amplifier having an inverting input coupled to said first voltage source and having a non-inverting input coupled to said second voltage source.

90. The temperature compensation circuit of claim 83, wherein said first temperature dependent voltage signal generator further includes:

a first dependent signal generator for generating a weighted signal dependent on the output from said second summation output node.

91. The temperature compensation circuit of claim 90, wherein said weighted signal is said first voltage signal of said first temperature dependent voltage signal generator.

92. The temperature compensation circuit of claim 90, wherein said first dependent signal generator is effective for producing substantially no output signal when the output of said second summation output node is less than a predefined threshold value, and producing said weighted signal when the output of said second summation output node is not less than said predefined threshold value.

93. The temperature compensation circuit of claim 90, wherein said first dependent signal generator is effective for producing substantially no output signal when the output of said second summation output node is negative, and producing said weighted signal when the output of said second summation output node is positive.

94. The temperature compensation circuit of claim 90, wherein said first dependent signal generator is a transistor having a control input responsive to said second summation output node.

95. The temperature compensation circuit of claim 90, wherein said first dependent signal generator is a current mirror having a control input responsive to said second summation output node.

96. The temperature compensation circuit of claim 80, wherein said first summation node is a summing amplifier having a first summing input coupled receive said first voltage signal and a second summing input coupled to receive said second voltage signal.

97. The temperature compensation circuit of claim 80, wherein said second temperature dependent voltage signal generator further includes:

a third voltage source; and

a second dependent signal generator for generating a second weighted signal dependent on the output from said third voltage source.

98. The temperature compensation circuit of claim 97, wherein said third voltage source includes a complementary to absolute temperature (CTAT) circuit.

99. The temperature compensation circuit of claim 97, wherein said weighted signal is said second signal of said second temperature dependent voltage signal generator.

100. The temperature compensation circuit of claim 97, wherein said second dependent signal generator is a transistor having a control input responsive to said third sub-signal source.

101. The temperature compensation circuit of claim 97, wherein said second dependent signal generator is a current mirror having a control input responsive to said third sub-signal source.

102. A temperature compensated oscillator comprising:

the temperature compensation circuit of claim 80;

a variable frequency oscillator responsive to the output of said first summation node.

103. The temperature compensated oscillator of claim 102, wherein said variable frequency oscillator is a surface acoustic wave resonator.

104. An electronic device including the temperature compensation circuit of claim 80.